REPORT

ON

WATERLOO SEWAGE TREATMENT PLANT

BY

ONTARIO WATER RESOURCES COMMISSION

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WATERLOO SEWAGE TREATMENT PLANT

This is a review of conditions encountered in the operation of the Waterloo Sewage Treatment facilities. This plant has now been in operation for a sufficient length of time to assess the problems arising and to examine means for correction of difficulties. A number of perplexing problems have been met, some of which must be expected when any new treatment works are put into service. Others have been due to local conditions, which are atypical of plants handling normal sewage. The incoming sewage is a strong one containing much industrial waste and varying in composition widely from hour to hour.

DESIGN FEATURES

Some information on design features of this plant is essential in the interpretation of present day conditions. The change from the former primary to the present secondary treatment was a most important one, in fact it is in any plant but more so here. In the former, the physical process of sedimentation is dominant but in the latter the biological processes can only function in a satisfactory environment, one in which there is food supply for the organisms responsible for purification, and there is no excess acidity, alkalinity or other deleterious constituent. Design of the works must provide the means in which this environment can operate.

Any sewage treatment plant must be designed for:

a) Hydraulic loading, i.e. according to the rate of flow of the sewage; both on an average and maximum .

b) Organic and solids loading generally measured in BOD and suspended solids.

In a primary treatment plant the hydraulic loading is important, but the organic load is of minor significance. In secondary treatment, as in an activated sludge plant, the solids and organic loads are of major concern. The efficiency expected of secondary treatment is much greater than that of a primary process. This high degree of treatment was found essential all along the Grand River.

DESIGN DATA FOR PRESENT PLANT

The conversion of the former primary treatment works to a biological activated sludge plant followed a study by the consulting engineers. This included flow data, strength of sewage, amount of solids and other features pertinent to the design. This was done in 1956. The information secured in the study was:

a) Population - 15,276.

b) Average daily 24 hour flow (all days) - 1.58 MGD.

c) Average daily 24 hour flow (working days) - 1.83 MGD.

d) BOD - Average 300 ppm.

e) Suspended Solids - Average 270 ppm.

f) No unusual acid or alkaline effects were revealed.

Based on this information, the new plant was designed for the following loadings:

a) Flow - 12 hour - 4 MGD average.

b) Raw Sewage Strength;

Avg. BOD - 300 ppm

Avg. S.S. - 270 ppm

On the foregoing basis, the loading on this converted plant was expected to be:

BOD -

a) Working days - 5500 lbs.

b) Average for all days of week - 4700 lbs.

Suspended Solids (S.S.)

a) Working days - avg. 4950 lbs.

b) Average for all days of week - 4270 lbs.

In an activated sludge plant, air consumption and power requirements are related to the strength of the sewage - the pounds of BOD to be oxidized. On the above quantities, the air requirements would be 2440 cfm. This can be compared with the capacities of the two blowers installed, each having a capacity of 3900 cfm.

Comparable figures for a normal municipal sewage may be considered as:

BOD - 200 ppm

S.S.- 200 ppm

Free Ammonia - 30 ppm

Examples of sewage anayses for other municipalities are:

	BOD	S.S.
Brantford	189	221
Stratford	265	239
Woodstock	390	220
London	217	264
Kingston	132	139
North Bay	160	169

	BOD	S.S.
Peterborough	185	191
Guelph	178	179
Kitchener	267	263
Galt	188	186
Toronto (Lakeview)	163	170

PRESENT DAY FLOW RECORDS

A comparison can be made of the loadings calculated at the time of the design of the plant, the loadings used in the design and present day loadings. These latter figures are important in a review of some of the problems experienced. Much work has been done by the OWRC to determine present day figures. These data may be summarized as follows:

a) Population - 20,562.
b) Average daily 24 hour flow (all days) - 1.8 MGD (1961)
c) Average daily 24 hour flow (working days) - 2.0 MGD (1961)
d) Maximum daily flow - 4.4 MGD (1961)
e) Average maximum daily flows - 2.8 MGD (1961)
f) BOD figures
    1) Average 1961 - 600 ppm
    2) Maximum 1961 - 1400 ppm
    3) Minimum 1961 - 125 ppm
    4) Average 1961 - (working days) - 654 ppm

g) Suspended Solids (S.S.) figures -

1) Average 1961 - 391 ppm

2) Maximum 1961 - 866 ppm

3) Minimum 1961 - 172 ppm

4) Average 1961 (working days) - 415 ppm

h) Free Ammonia figures -

1) Average 1961 (working days) - 25.7 ppm

The changes taking place in the content of this sewage since the design basis was fixed are as follows:

	Population	Avg. Weekday Flow	Avg. Weekday BOD	Avg. Weekday S.S.	Avg. NH_3
1) 1961 Data	15,276	1.83MGD	300 ppm	270 ppm	
2) Design Figures		4.0 MGD	300 ppm	270 ppm	
3) Present Figures	20,562	2.0 MGD	600 ppm	391 ppm	25.7 ppm
Increase over Design Basis		Excess of 2.0 MGD Hydraulic Capacity	300 ppm	121 ppm	

From these figures it can be seen that the most significant increases over the design figures are:

BOD - 300 ppm average and up to a maximum of 1100 ppm.

S.S.- 121 average and up to a maximum of 596 ppm.

The above increases are for the average weekday, whereas if the working days of the week are taken, as they should be, the increase is substantially greater.

INDUSTRIAL WASTES

Full consideration must be given to the amounts and nature of the industrial wastes reaching this sewage treatment plant. Domestic sewage is relatively constant in those ingredients which bear on treatment plant efficiency and cost. Industrial wastes may either add a high organic load which requires more oxidation through the consumption of air and power, or they may cause interference with the normal operation of such a biological process as in the presence of strong acid or alkaline wastes, the absence of sufficient ammonia to provide a suitable environment and food for biological growth, or by the presence of other interfering substances. The extent to which industrial wastes may affect plant operation will depend a good deal on the dilution of these wastes with the domestic sewage. In a large city such as Toronto or Hamilton, the industrial wastes of any one kind are not so noticeable nor do they have the same pronounced effect on the purification processes.

In Waterloo, there are relatively large volumes of industrial wastes, which vary widely from hour to hour in composition, and which can create a pronounced effect on the operation of this process.

Some data on these wastes are recorded herewith as observed in the analyses of samples collected by the OWRC. The most significant are:

a) The Brewery -

Waste discharge - 794,000 gallons per day

Average BOD - 1220 ppm

Average Suspended Solids - 469 ppm

BOD to nitrogen ratio - 28 to 1

pH - 4.1 to 12.3

Wide variations were found in some of these wastes, running as high as 80,000 ppm BOD and 3670 ppm suspended solids.

b) The Distillery -

Waste discharge - 50,000 gallons per day

Average BOD - low - 50 lbs per day

- about 120 ppm

Average Suspended Solids - small -

pH - 1.0 to 13.0 of parts of the wastes

The practice of discharging the spent caustic in short periods produces a high pH in the sewer and in the wastes reaching the sewage treatment plant.

The combined effects of these two major industries may be seen in the discharge of high flows to the sewers, very high BOD and S.S. at the sewage plant, extremely wide variations in pH and a lack of nitrogen in proper proportion to the BOD load. The wide variations are abnormal for sewage treatment, and have a most deleterious effect on the activated sludge process.

THE SEWAGE TREATMENT PLANT

Some comments on the operating problems at the plant itself are called for. In the first place, it must again be emphasized that a secondary sewage treatment plant such as this is vastly different in operation from the former primary treatment works. It is a delicate operation requiring technical skill and laboratory facilities. The problems are enhanced when difficult industrial wastes are present.

Any new treatment plant is likely to have difficulty in the "breaking-in period". Sometimes these are quite acute and require an extended period of adjustment, in others the problems can be overcome without too much difficulty. Equipment problems in some plants are intense, as is likely to be the case in any new piece of complicated machinery. These problems must be expected in all such works. The important part is that they shall be corrected as effectively and as quickly as possible. In the Waterloo plant, an abnormal amount of breaking-in difficulties were encountered. Part of this was due to conversion from an old plant, and part to the equipment and the changes in the process.

Some of these problems may be listed as follows:

1) The type of wastes.

2) Mechanical equipment.

3) The primary clarifier.

4) Sludge digestion.

5) Final disposal of sludge.

Difficulties in mechanical equipment were centred chiefly in the skiphoist for transporting sludge, and the noise in the air blowers. The former was the responsibility of the manufacturer and it has now been rebuilt. Present reports are satisfactory. The blowers have been noisy, and vibration has been difficult to control. Different measures have been used to reduce this. Other equipment has been adversely affected by the nature of the sewage.

The primary clarifier is the one used in the former plant. It did not fit entirely into the design capacity of the new plant, and being only one unit did not possess flexibility. When the tank has to be dewatered for repairs the raw sewage goes directly to the aeration tanks and causes a further overload there. This would be less of a problem if the sewage were normal in strength. The underwater parts of the mechanical equipment have been in poor condition, induced chiefly by the corrosive nature of the incoming sewage. The operating results on this clarifier have been quite ineffective. Its use in the works was an attempt to economize on capital costs.

The sludge digestion facilities of the former works required a substantial expenditure to fit them into the new plant. It was agreed to defer that expenditure until the filtering process on the raw sludge might be tried. On a normal sludge, this method is quite feasible and thereby saves the cost of the digestion tanks. The old tanks could be used for storage of sludge at peaks, but they were loaded with sludge so compacted that it was time consuming and expensive to have it removed. In fact, it is still not all out of the digesters.

The major difficulties arose from the nature of the sewage brought about by the content of industrial wastes. The way in which this has affected plant operation is detailed later in this brief.

Final disposal of the sludge from the vacuum filter creased problems of odour and costs. These can be related to lack of facilities, brought about by deferment of capital costs.

The foregoing outlines some of the reasons why difficulties have arisen in the operation of this new plant. There is need to consider both what is to be done at the plant itself and in the control of the raw sewage. Since the most significant factor is the industrial wastes, the effects of these must be examined.

EFFECTS OF INDUSTRIAL WASTES

The industrial wastes at Waterloo constitute both a substantial percentage of the total daily flow at the sewage works and a high organic and chemical loadings. In the report of the consulting engineer in 1956, it was stated that these two industries contributed a daily flow of 0.54 MGD or 30% of the total for working days. The consultants in referring to the BOD of 300 ppm in 1955 and slightly less in the two previous years, as well as the suspended solids of 2.76 in 1955, 281 in 1954, and 259 in 1953 said, "We believe that the relatively high BOD and suspended solids of the sewage entering the plant can be accounted for by the strong industrial wastes from the brewery."

Detailed information on these industrial wastes is contained in reports in 1960-61 by the Industrial Wastes Branch of the OWRC. At that time, these wastes had, as previously stated, reached the following proportions:

a) The Brewery -

Flow - 793,800 gallons per day.

Analyses - 9,685 lbs. BOD per day

3,720 lbs. S.S. per day

b) The Distillery -

Flow - 50,000 gallons per day

Analyses - 50 lbs BOD per day

negligible Suspended Solids

By combining these two wastes together in the sewers, the total results is a flow of 843,800 gallons or 42% of the total flow reaching the treatment plant. The BOD loading during weekdays totalled 9,735 lbs. or 75% of the total BOD in the flow. Similarly the suspended solids during weekdays reached 3,720 lbs. or 45% of the total inflow to the sewage treatment works.

While the loading itself constitutes a serious factor, the situation is further aggravated by the discharge in batches or slugs of strong acid and alkali wastes. The distillery discharges a calculated 1,740 lbs. of spent caustic per week, but this comes in batches over periods of one-half to one hour. At the distillery, the alkaline wastes discharged are calculated at 4,000 lbs. per week, thus making 5,740 lbs. for both industries per week. Batches of acidic wastes are also discharged from the distillery. At the brewery, the acid wastes are neutralized. The acidic wastes, apart

from any possible effects on the treatment process, can cause serious action on concrete sewers.

Representative concentrations of these periodic discharges of acidic and alkaline wastes is shown in pH measurements at the treatment plant. The pH is known to fluctuate between a low of 3.0 and a high of 12.0 +. Of note is the recording made on October 27, 1961 when the pH changed from 3.2 at 3:15 PM to 11.7 at 4:30 PM, a time lapse of only 45 minutes.

PRESENT LOADING VS. DESIGN CAPACITY

From the preceding information, it is apparent that a change in the sewage composition has taken place over the figures available to the consulting engineer at the time the design was prepared. There was a substantial margin provided in the design as is normal in all such plants. The question now is how does the present loading compare with the design capacity, and what, if any changes are necessary to enable the plant to operate efficiently and to produce the desired effluent at a minimum cost. These loading figures are as follows:

	Design Capacity	Present Loading (Avg.)	Surplus or Deficit
MGD Flow (Working days) Average	4.0	2.0	+2.0
MGD Flow (Working days) Maximum	4.0	4.4	-0.4
BOD (lbs/day)	12,000	11,700	+ 300
S.S. (lbs/day)	10,800	8,300	+2500

The conditions created by the flow of domestic sewage and industrial wastes are as follows:

1) The hydraulic loading on the plant now at an average of 2.0 MGD is still well below the design capacity of 4.0 MGD, but the industrial waste flows produce abnormal peaks at times in excess of the designed capacity and thus require a higher than usual design capacity.

2) The BOD average concentration for 1961 was double the figure used in the design and the peaks were much above this. The total design BOD loading of 12,000 lbs. per day is based on each part of the plant doing its part while the average BOD for weekdays was still about 12,000 lbs., the average maximum daily flow was 16,800 lbs and at the maximum daily flow was 26,400 lbs. The original design was predicated on effective action by the primary clarification, normally in excess of 30% removal. The results show very inferior results which in turn mean a higher load on the aeration tanks with more power and greater costs.

   The BOD loading on the aeration section is therefore calculated to be 17,300 lbs. per day.

3) The suspended solids follow a somewhat similar pattern to that of the BOD. The average design loading of 10,800 lbs per day can be compared with the much higher concentration of solids (391 ppm) for a weekday load or a total of 7,820 lbs., a maximum daily load of 17,200 lbs.

or an average maximum daily figure of 10,950 lbs. The wide fluctuations again are important.

An effective primary clarifier might be expected to remove 60% of the suspended solids, whereas this old unit gave very inferior results, with the effluent averaging much of the time a higher figure than the influent. Fluctuations in the sewage have a strong influence on these results.

4) Fluctuations in pH

The pH (hydrogen in concentration) of the sewage, being strongly influenced by the industrial wastes, has varied widely from a normal sewage having about 7.3 pH to an acid condition of 3.0 and to an alkaline state as high as 12.0. The most critical factor in the pH has been the shock loads which tended to interfere with the sludge and to prevent purification. Under those circumstances, not only are poor results secured, but odours, bulking and discharge of sludge to the stream will occur.

5) Sludge Volume and Disposal

The higher suspended solids in the sewage created more volume to be handled by the sludge filter, which in turn called for more chemicals and higher costs. The composition of the sludge made it more difficult to filter in the raw state.

Final sludge disposal by dumping on farmland or at the city dump had limitations. Odours were obnoxious when it was left uncovered on the surface of the ground.

If this had been digested, the odours would not have been present.

6) Higher Operating Costs

Since the operating costs for the Waterloo plant exceeded those placed in the budget at the first of the year, these should be examined in the light of conditions experienced in the treatment of this sewage. Details have already been given on some of the major deviations from the budget. They are due primarily to the nature of the sewage and to activities associated with the conversion of the old plant.

REMEDIAL MEASURES AND RECOMMENDATIONS

The foregoing provides information on the conditions which exist in the treatment plant itself, the nature of the sewage and the capability of the plant to meet these requirements. It now becomes necessary to find a satisfactory answer, one which will produce a suitable effluent, and which in turn will protect the river against objectionable pollution, and all to be done at the lowest feasible costs.

It is clear that "industrial" wastes are a major factor in this entire situation. A decision is necessary on such matters as:

a) Should these be accepted into the public sewers?

b) If accepted, what preliminary treatment should be given at the industry or by the municipality?

c) Must provision be made at the sewage treatment plant to treat these wastes without any restrictions being applied, either in respect to quantity, strength, or rate of discharge?

It may be stated that as this province grows industrially, there is a distinct trend of having industrial wastes treated with the municipal sewage, but with whatever preliminary treatment may be necessary and this to be done either by the municipality or the industry. The decision in respect to this is naturally a policy one for the municipality to make, so long as it is feasible to provide the required treatment facilities, and to incur the cost of doing this. There are many examples of this practice now in Ontario.

The measures recommended are as follows:

1) Control of Industrial Wastes

This is the first requirement for successful operation of these treatment works. This can involve the following:

a) Pretreatment to a limited extent at the industries and before the wastes reach the public sewers.

b) Adoption of a policy in respect to the acceptance or otherwise of industrial wastes into the sewers, upper limits for the contents of such wastes, methods of charging for their treatment, responsibility of treatment upon the city or the industry, and all

related matters likely to affect the treatment plant operation.

c) The <u>control of "slugs"</u> of concentrated industrial wastes containing abnormal pH or excess quantities of organic material. Such discharges call for either a high capacity plant or result in interference with the process. This can be done by neutralization of wastes, and the use of storage tanks for spreading out the flow. These acidic and alkaline wastes not only affect the treatment plant but also the inlet and outfall sewers.

2) <u>Alterations at the Sewage Treatment Plant</u>

When a program is adopted on the handling of industrial wastes the necessary changes at the treatment plant should be put into effect. They are:

a) Alterations to the primary clarifier to improve its efficiency, its hydraulic design and overcome the effects of corrosion of the metal parts and the provision of additional sedimentation facilities to relieve the load on the aeration tanks.

b) Increase of aeration tanks capacity unless the organic loading can be reduced or made more uniform.

c) Correction of nitrogen deficiency in the sewage to be treated unless changes in the control of industrial wastes prove to be otherwise effective.

d) Rehabilitation of the sludge digestion tanks for treatment of the sludge.

e) Better control of final sludge disposal to avoid odour nuisances, and to ensure minimum costs. The general objective should be to have this material returned to the land for use as a fertilizer.

f) The use of a program of regular maintenance of equipment at the sewage works. Because of the character of the raw sewage much of the equipment was in very bad condition when the plant was taken over by the OWRC. This included the sewage flow meter, the grit chamber rakes, the primary sedimentation tanks, the digester tanks, and other parts.

g) The inlet sewer and the outfall to the river have been adversely affected by the nature of the sewage. These will require a program of renovation and replacement.

h) Equipment installed at the new plant has required a high cost maintenance because of the nature of the sewage, and this will continue unless there is better control of the industrial wastes. Some parts may be cited as examples - raw sludge pump, the air blowers, the vacuum pump and filtrate pump, the sludge filter and the chemical pumps.

i) The very hard water available from a well at the premises has interfered with the coil filter and vacuum pump.

j) Suitable facilities for the staff at the treatment plant were not provided. These were eliminated for economic reasons. They should include an office for the chief operator; locker room and lunch room facilities and reasonable toilet and shower facilities.

k) The foregoing and other matters at the sewage treatment plant will require constant assessment. This can best be met by close cooperation between the Local Advisory Committee and the staff of OWRC's Plant Operations Division.

SOME OPERATING RESULTS

It can be seen from the foregoing that extremely difficult conditions have been imposed on the operation of this sewage treatment plant. In spite of this, the results obtained have been gratifying. When intolerable conditions arose, the plant could not possibly function properly, but it did show strong recuperative properties once these conditions passed. There is every indication that given reasonable loadings the treatment works will produce excellent results and will do all that can be expected. It must be emphasized that no activated sludge plant can do the impossible, and when adverse conditions are met the final results are inferior and the costs are increased.

Some of the operating results secured are listed herewith for general information.

EFFLUENT SAMPLES

Interference by Industrial Wastes

DATE	5 DAY BOD	SUSPENDED SOLIDS
October 12, 1961	350	696
October 13, 1961	660	1052
October 25, 1961	900	1130
October 26, 1961	660	1122

No Interference by Industrial Wastes

DATE	5 DAY BOD	SUSPENDED SOLIDS
September 15, 1961	15	58
September 22, 1961	11	42
September 25, 1961	15	36
September 28, 1961	7	60
October 22, 1961	11	58
December 21, 1961	10	50

SUMMARY AND CONCLUSIONS

This lengthy report was prepared to set out the conditions encountered in the treatment of the unusual mixture of sewage and industrial wastes being received. In brief summary, it may be stated that the change in the loading from the time of the design

to the present, effected in large measure by difficult industrial wastes, has interfered greatly with successful and economical operation. The facilities of the OWRC through its laboratory and skilled technical personnel have been applied to this problem continuously and at no cost to the city. It would be difficult to visualize what would result if these facilities were not available. Extra costs were incurred in 1961 as a result of corrections needed in the old plant. The time has now come when the "breaking-in period" should be over, when the assessment of difficulties has been determined and when an answer must be given to these problems. The city has control of its own sewers and what it wishes to do to control the wastes. It is clear that these works can produce good results if given an opportunity. This briefly is the conclusion reached. What will be done to correct it?